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A TOUR OF RUSSIAN OIL FIELD TECHNOLOGY*

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ABSTRACT

As part of U.S.-U.S.S.R. efforts to define potential areas for cooperative projects in energy research and development, oil experts from the U.S. and the Soviet Union exchanged visits. An overview of some aspects of Soviet oil field technology that was gained from a tour of major administrative and technical institutes and three major oil centers in Western Siberia, Baskiria, and Tataria is presented. This paper presents the highlights of the tour, comments on Soviet drilling technology, compares U.S. and Soviet drilling equipment and practices, and recommends areas for cooperative projects in oil technology.

INTRODUCTION

About two years ago exchange tours were arranged by the American and Soviet governments to attempt to define potential areas of research and development in oil technology which might be of mutual interest for cooperative projects. This exchange of visits and discussions by oil experts from the two countries was part of a larger effort under the 1974 U.S.-U.S.S.R. Energy Agreement, and was one element of many in our Nation's contribution to "détente." The Soviet members of the "Temporary Group of Oil Experts" were hosted in their visit to the U.S. by ERDA and several major oil companies; the U.S. members were hosted on the visit to the Soviet Union by the Ministry of the Oil Industry. This organization directs all Soviet exploration, development, production, and distribution efforts, although production planning is centered in GOSPLAN.

We requested, and received, a tour which included a representative sample of Soviet petroleum engineering colleges, centralized ("all union") research institutes and facilities, administrative centers, regional R&D centers, support institutes, older operating oil fields and new fields under development (in Western Siberia), operating drill rigs of various capabilities, separation plants, repair and maintenance shops, and the personnel involved in the Soviet oil "industry".

The tour and preparation of this paper were conducted under the auspices of the U.S. ERDA.

References and illustrations at end of paper.

This paper presents the highlights of that tour and focuses especially on examples of Soviet drilling hardware and related technology. Such an emphasis serves to indicate fairly concretely the nature, status, problems, and successes of the Soviet thrust to develop their vast energy resources. Demands on the Soviet's oil production are rapidly increasing, especially from their expanding highway transportation network[1], commitments to Eastern Europe, and expansion of energy-intensive industries[2,3]. This pressure is being felt in all elements of the Soviet oil production activities, particularly drilling.

MOSCOW

After a one-day stopover in Amsterdam to organize and brief the U.S. group and especially to provide our interpreter with the technical vocabulary and terminology likely to be used, we arrived in Moscow and immediately experienced the splendid hospitality and very effective organizational capabilitities of the Soviet Oil Ministry. The members of the "Temporary Group of U.S.S.R.-U.S. Oil Experts" met to renew previous acquaintances made during the Soviets' visit to the U.S., to learn of the organization of the Soviet' Oil Industry, and to review the itinerary for the tour (Figure 1) of the Soviet Union's oil technology.

The administrative and operational aspects of exploration, development, production, and research and development in the various Soviet oil fields are apparently organized along similar lines. A simplified diagram of this set-up is illustrated in Figure 2. The tour was to cover three of the largest oil-producing regions and the oil centers, towns and fields in these districts as indicated in Table 1. As shown, there exists in each element and level of the organization a drilling office or department.

Our day in Moscow concluded with a visit to the All-Union Scientific Research Institute for Drilling Technology (VNIIBT). This institute, called the "Temple of Russian Drilling Technology," had recently had its goals dramatically shifted from concentration on research in advanced methods (some thirty projects), to the objective of improving current drilling equipment and practices. The aim is to produce more holes per

rig. We were told that primary emphasis was being directed toward optimizing drilling hydraulics and improving turbodrills. The turbodrill and other downhole motors remain the dominant drilling method in the U.S.S.R., and we learned that their average drilling depth has been increasing; 1.2 km in 1965, 1.9 km in 1970, and probably greater than 2.0 km after 1975. Thus, there is a trend to attempt to reduce downhole motor rpm and increase torque to extend bit life and reduce round trips. We were told that about 50% of all current completions involved directional drilling.

We learned that about 300 professionals are employed at the VNIIBT in Moscow and about 2,700 more are associated with the institutes in district oil and gas centers. Field test drilling research laboratories, with a dedicated rig, exist in eight of the district centers, which represent the geology and drilling conditions of the thirty different oil-producing regions of the Soviet Union. These facilities are used to solve specific drilling problems, optimize drilling strategy, and test modified or new equipment.

WESTERN SIBERIA

We arrived in Tyumen, Western Siberia, very early on a cold, sleety August morning. Tyumen (Figure 1), a city of perhaps 350,000 population, is the major center for the extensive development and production of new oil fields in Western Siberia. Over fifteen years ago, as the plans to develop the regional resources matured, Tyumen was established as the administrative supply, maintenance, and technical base camp for the operations.[4] A very large coal-fired power plant was built there, supplied by rail from the mines in Central Siberia, east of the Ob River[5], as shown in Figure 3. This power plant complex then extended transmission lines into the Tyumen district to provide power for drill rigs, water flood pumps, freight barge unloading cranes, cities, maintenance yards, separation plants, and to support and operate the other equipment and activities required for the development of a major oil-producing region; an area equal to about that of the state of Alaska!

The research and engineering groups at the Tyumen institutes briefed us on the exploration difficulties. The climate of the region is notoriously hostile: an average of 200 days a year below freezing and extended periods with the temperature remaining below -40°C. But the primary obstacle is that about 60% of the area of Western Siberia is a vast, very deep swamp, especially those regions near the Ob River where the major oil pools have been found. It took about five years of research and development in the field to provide a possible, but very expensive, solution for oil field development in this swamp. This solution is illustrated in Figure 4, which shows the road construction practice. First, peat is heaped up from the swamp bottom along the road bed; logs are laid in corduroy fashion across the peat; a sand layer is trucked from the Ob River and its tributaries, where it is pumped up by barge dredges; finally, precast, reinforced concrete slabs are laid to form the roadway. The truck in Figure 4 is hauling a load of these surface slabs. A third trench may be constructed to accommodate oil production and water flood pipelines, and utilities. Drill pads are also built in this manner (Figure 5).

After these thorough and fascinating briefings we traveled to the oil town of Nizhnevartovsk (Figure 3) and the Samotlor oil field. Nizhnevartovsk was an old hunting village of 2 dozen or so log huts in 1961 at the time that the discovery well tapped the super giant oil field under Lake Samotlor ("dead lake" in the Khanty tongue). We toured many of the supply facilities, control centers, separation plants, and pumping facilities in the area. All structures and equipment were supported over the swamp: power poles on driven concrete posts, tanks and apartment buildings on piles and special foundations. Nizhnevartovsk is now a bustling, booming, rapidly growing town of perhaps 75,000; and it never sleeps because the oil field development is being pushed at a rapid pace. No highway or railroad had reached the town at the time of our visit. We arrived by jet at the large airfield, where many freight helicopters were evident. The runways were also constructed in the peat-logs-sand-slab fashion.

The major supply route of Western Siberia is the River Ob, which can be used only during the summer months. The river was covered with anchored barge loads of supplies: casing, concrete slabs, pre-fab buildings, etc., awaiting unloading at the large port facility at Nizhnevartovsk. This barge traffic comes from Novosibirsk on the Trans-Siberian railroad, and is fed from industrial centers in the Ural and European Russia regions and the Eastern European countries.

Of primary interest is the Soviet drilling equipment and practice at Samotlor. Figures 6 and 7 show a VAS-42M drill rig in operation there and a sketch of the derrick with size and capacity data. This is the standard configuration for the development drilling equipment in the Western Siberia region. The Soviets use turbodrills (Figure 8) and drilling is reported to be relatively trouble free. The reservoir is at a depth of about 2.2 km (7000 ft). Directional drilling is practiced for most wells, with as many as forty wells drilled from one of the (expensive) locations. The rigs are mounted on several large pipes and skidded laterally about 3m (10 ft) for each new well. The rigs are heavily winterized. The drilling crews appeared to be somewhat limited in manpower. The rigs were highly automated, which we were told was to compensate for the shortage of trained drillers and to aid operations during bad weather. The equipment was in good condition and repair, with the possible exception of the rubber mud line which we were told was relatively new, but if so, was of low quality. A large stock of tri-cone toothed and carbide button bits was on the rig floor, even though we had been told in Moscow that only two bits per well were required in Samotlor. The all-electric rig was notably quiet when in operation.

The crews and personnel that we contacted in Western Siberia were quite young, dedicated, knowledgeable about, and proud of their contributions to the U.S.S.R.'s economic and energy futures. They appeared to have good back-up by the Oil Ministry at all levels; and equipment, services, maintenance, and materials were in good supply.

During our visits in Western Siberia, and as we left Nizhnevartovsk for the airport, we observed a number of very large gas flares. We were told that

these were due to a temporary gas pipeline problem; however, visitors to the area before and since have reported this extensive flaring, and it seems more likely that this gas production awaits completion of more gas pipeline capacity and a natural gas fired power plant at Surgut - located west of Nizhnevartovsk, Figure 3), and frequently discussed by the Soviets[3].

BASHKIRIA AND TATARIA

The Soviet oil-producing region to the west of the southern end of the Ural Mountains is rather arbitrarily divided into two administrative districts: Bashkiria and Tataria, arbitrarily divided because the oil formations are essentially the same and several fields extend across the boundary (Figure 1) of the two districts. (These two Soviet Republics are the modern extensions of the khanates of two of Chengis Khan's followers.) Both oil fields are relatively old and in advanced stages of development.

Our first stop was in the Bashkirian Oil Center of Ufa (refer to Table 1). We were received very cordially and given a most thorough briefing and tour of the administrative and scientific institutes. Of major interest was their drilling research laboratory (Figure 9), one of the eight described to us in Moscow. This shows a VM-41 derrick (we will discuss this type of drill rig later) permanently installed over a laboratory building. Large rock samples were available, masses to provide weight on test assemblies, a mud system, and recording equipment. Tests of turbodrills, bits, downhole assemblies, etc. could be performed. We were told that the laboratory was most useful as a means for solving drilling problems encountered in the Bashkirian and Tatarian fields. We also learned that the Oil Ministry regional scientific and research institutes served as teaching and degree granting institutions, granting up to a level roughly equivalent to a U.S. master's degree.

We then traveled by highway to western Bashkiria to the oil town of Oktyabriskiy (population of about 75,000) and the Tumazi oil field. The field has been producing since 1929, and currently production is dropping. There are about 10,500 wells; about 2000 are used as water injection wells for line drive, another approximately 2000 wells have downhole pumps, and a majority of the production wells have pump jacks installed. The tour included production control and monitoring facilities, pump stations, separation plants, and the original discovery well, which was prominently displayed with the old pipe derrick still intact. We also visited well number 100, which in 1944 discovered the deeper, very productive, Devonian sand formations. Most of the drilling in the subsequent thirty years was accomplished with the pipe-and-connection derrick (Figure 3) fabricated on the location, and left over the well during production. This type of drill rig is still apparently used for much of the Soviet's exploration drilling.[5] Tumazi No. 100 well had a suitable plaque to commemorate its feat and was equipped with a Lufkin pump jack.

Our hosts from Tataria picked us up in Oktyabriskiy; we crossed the Ik River into Tataria and drove to their regional oil and gas center in the city of Bugulma. We received the now very familiar briefings and tour of the institutes. Tataria has an especially well-equipped and well-staffed research and development establishment. Indeed, it had the character of a stable, self confident, highly professional organization. It seems that most of the field research and development projects for the oil and gas ministries are carried out here. We then traveled to the oil town of Almetyevsk and toured the associated Romashkino oil field. This field is even older than those in Bashkiria, with a production history of about forty years. For many years Tataria was the U.S.S.R.'s largest producing region; only recently surpassed by Western Siberia. The tour of the oil field followed the now familiar pattern and indicated that the facilities were somewhat older, but perhaps more substantial than the ones in Bashkiria. There was an obvious element of a proud tradition in being the U.S.S.R.'s largest producing region for so many years, and this attitude was reflected in all the staff and workers we met.

Two drilling-related items were especially interesting. In Almetyevsk we inspected a turbodrill repair and maintenance shop. This capability is presumably provided in each oil town in the Soviet Union. The facility consisted of: an outdoor shipping and receiving area, a cleanout and test sump, a large thread lathe, a spare parts area, and a housing removal machine. Complete repairs and refurbishments, including replacement of stators and rotors, could be performed. We were told that the rate of turbodrill repair was between 2 to 5 units a day. Of special interest with respect to advances in drilling technology were the two racks of nine-lobbed, positive displacement (Moineau-type) downhole mud motors stored in the shop. Figure 10 shows one rack of new rotors and housings (stators); the other rack contained used components. Our hosts indicated that these development motors were undergoing field tests and were expected to out-perform turbodrills, but few details were forthcoming to our questions.

We also visited the site of the drilling of a deep stratigraphic well. A big rig, as shown in Figure 11, with a normal depth capability of 5 km (15,000 ft), was using aluminum drill pipe to extend its capacity to 7-1/2 km (24,000 ft). Figure 12 gives some details of the rig. This was obviously a showpiece of the tour, and we were informed that plans were to have a stratigraphic well drilled in each of the major oil and gas regions of the Soviet Union. This project is somewhat similar in objectives to the proposed U.S. Continental Drilling Project.[6] Our hosts indicated that a hole to 7-1/2 km had already been completed in the Baltic region and was being deepened by a special "giant" rig to a 15-km depth. The rig in Tataria was at about 3-1/2 km and drilling ahead in the hard crystalline granite basement rocks. The tool pusher had a large stock of carbide button bits on hand and indicated that drilling was rather slow and round trips frequent for replacement of drill bits.

MOSCOW WINDUP

We returned to Moscow with a brief stopover in Kazan, capital of the Tatar ASSR. Upon our return to Moscow we visited six more of the Oil Ministry institutes. Two are of special interest for this overview. The All-Union Scientific Research Institute of Oil and Gas is apparently the top planning and evaluation staff for the Oil Minister. Data on all production are reported daily to this center; we had seen the telex machines in the various oil field control rooms. Drilling data for all operating rigs are also

transmitted and recorded at the Institute. It has several large computers and synthesizes the data on a national basis, makes predictions, and perhaps spots problem areas. It also sets individual field production goals, operates reservoir models, and evaluates drilling and production strategies.

The other "Institute", the College of Petroleum and Gas Engineering (the Gubkin Institute), is the major petroleum teaching and research organization in the U.S.S.R., with about 12,000 undergraduate students. As a part of the tour of the college we visited the Department of Drilling Engineering and inspected and were briefed on their mud, rock mechanics, drill bit, drilling mechanics, cementing, boring, hydraulics, and other drilling-related teaching programs and facilities. This is a very prosperous college department, and has as its most well-known graduate the current Minister of the Oil Industry, V. D. Shashin. The laboratories are very well equipped, and in the lobby of the department is an operating-scale model of a VAS-4ZM drill rig.

During the final meeting with the Soviet half of our group of experts we agreed on a list of five areas which might be potential areas for collaborative research and development:

- Methods of increasing petroleum recovery (tertiary methods and others).
- Radiometric and geochemical exploration.
- Geomicrobiological methods of prospecting and production stimulation.
- Basic properties of petroleum.
- Methods of extraction of petroleum from deposits of heavy oils and bituminous sands.

The final event of the tour was a presentation by the U.S. Chairman, J. Wade Watkins, entitled "Overview of Petroleum Industry of the United States," which was attended by the Oil Ministry Senior Staff.

DISCUSSION

From observations on this trip, and review of the literature, it seems clear that the Soviets' major energy resources are still coal, natural gas, and hydroelectric; and the country produces most of its electric power from these sources. Currently the U.S.S.R. is the world's largest producer of oil. Much of this oil is supplied to Eastern Europe, and the Soviet Union receives food, manufactured goods, tools, and machinery in return. It is also apparent that the Soviets are making a very significant effort to expand oil production on every front: exploration, drilling, field development, and enhanced recovery (all new fields are placed on water drive, and most older fields have been modernized to this stage.)

In drilling technology, it was clear that there was an intensive push to increase rig productivity in every way. Their increased deeper drilling demands are inclining them toward rotary drilling. The need for more and improved drilling equipment was evident in all phases of oil field drilling development. They are very aware of U.S. technology and equipment and have access to our journals and trade magazines; the drillers in the field would certainly like to get their hands on U.S. quality and quantity drilling goods and services. Their drilling efforts are accomplished in a rather methodical, highly planned and institutionalized manner. Rigs and crews are assigned to a field or region for a long period. The crews live rather comfortably (by Soviet standards) in designated apartment buildings, and commute to the nearby oil town by "company" bus at shift change. The Soviets appear to be doing development work in diamond core bits, cements, hard rock button bits, turbodrill optimization, and rig automation. Indications were that the Soviets would like to be able to tap U.S. drilling technology and equipment.

ACKNOWLEDGEMENTS

We would like to thank our hosts the Oil Ministry for a well-organized and informative visit. The interpreter in our party, Mrs. Nataly Martin, did an extraordinarily effective job, and contributed immeasurably to the communications between our group and the many Soviets we met.

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TABLE 1

RUSSIAN OIL TECHNOLOGY TOUR OUTLINE

DISTRICT & OIL CENTER	LOCAL OIL TOWN	OIL FIELD	ESTIMATED 1976 OUTPUT of DISTRICT, (b/d)
TYUMÉN (WESTERN SIBERIA)	NIZHNEVARTOVSK	SAMOTLOR	3,620,000
UFÁ (BASHKIRIA)	OBTYABRISKIY	TUYMAZI	600,000
BUGULMÁ (TATARIA)	ALMETYEVSK	SHOGUROVO	2,040,000

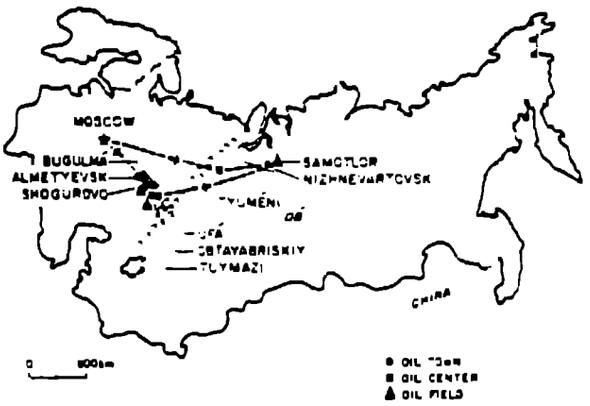


Fig. 1 - Sketch map of Soviet oil technology tour.

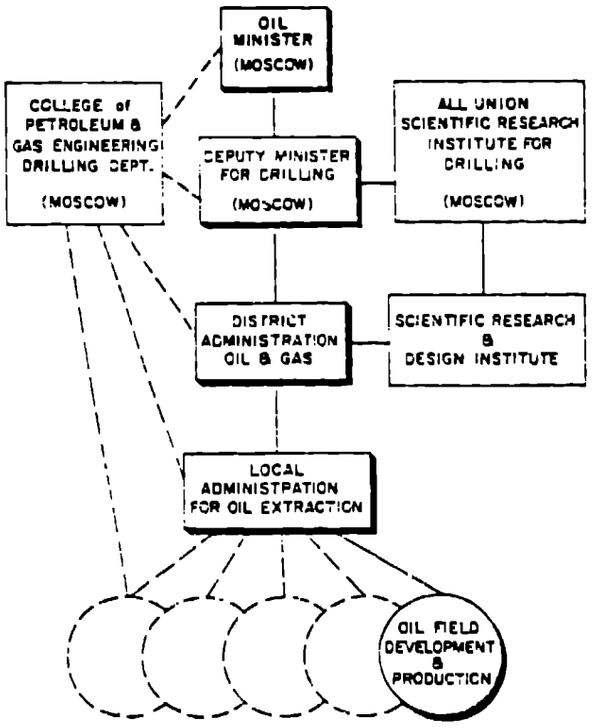


Fig. 2 - Simplified organizational chart of Soviet oil and gas drilling activities.

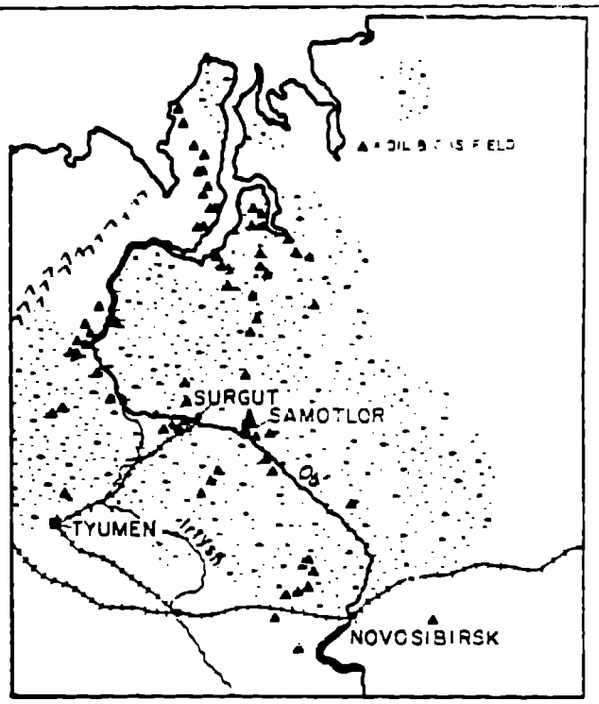


Fig. 3 - Map of Western Siberian oil district.

Fig. 4-Road construction over swamp in Samotlor field.

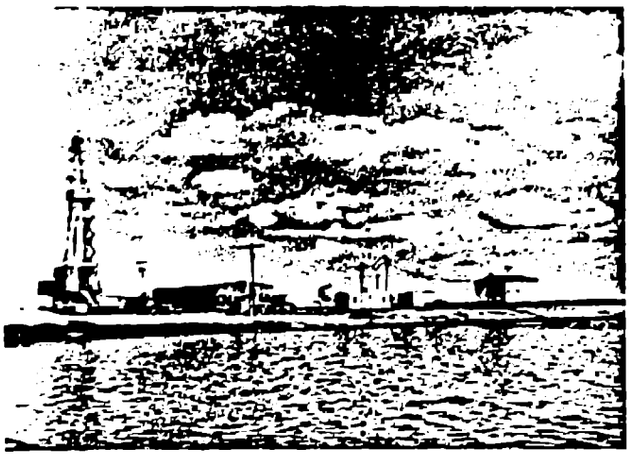


Fig. 5 - Built-up drill pad in Samotlor field.

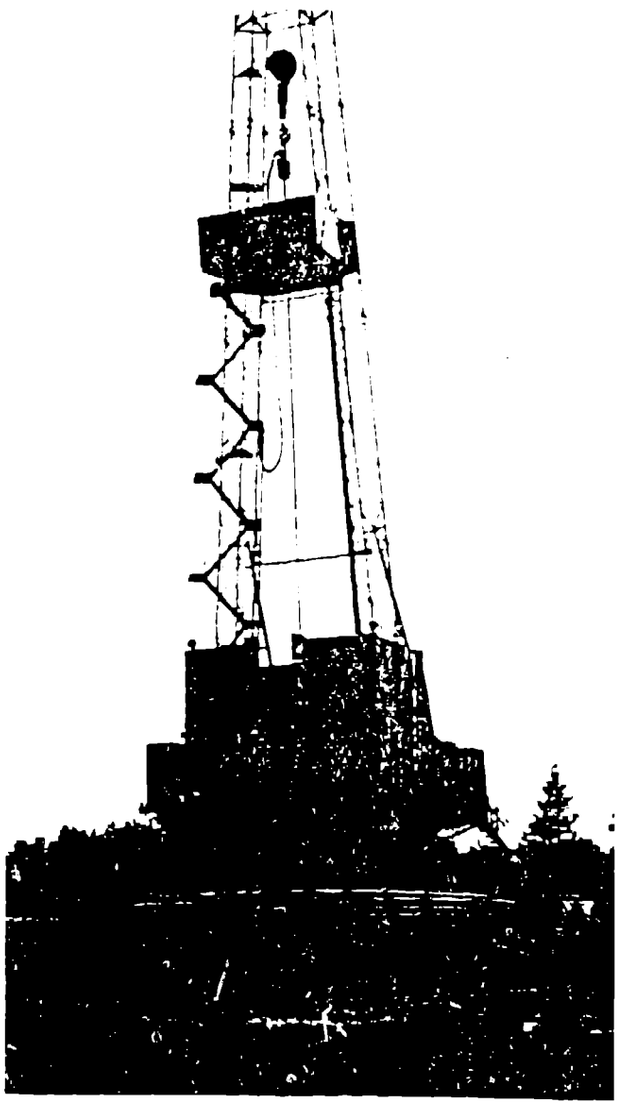


Fig. 6 - Photo of VAS-42 drill rig at Samotlor.

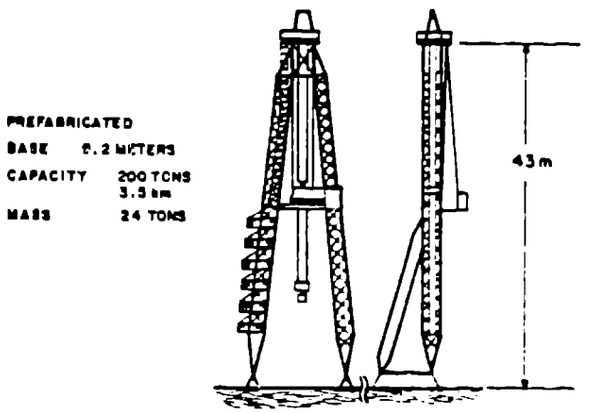
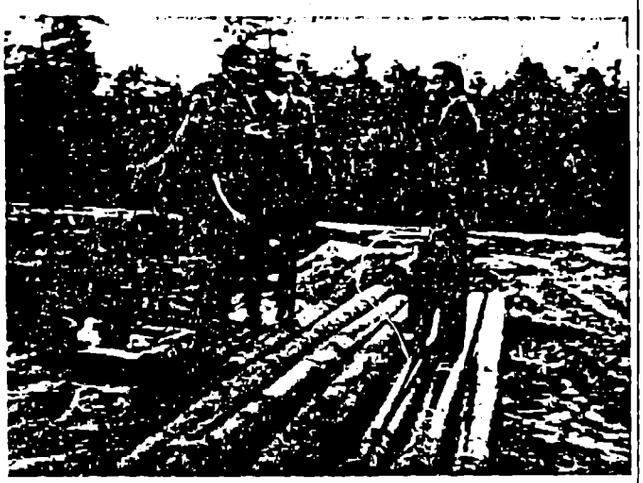


Fig. 7 - Diagram of VAS-42 derrick and specifications.



ig. 8 - Samotlor, stack of turbodrills on location.

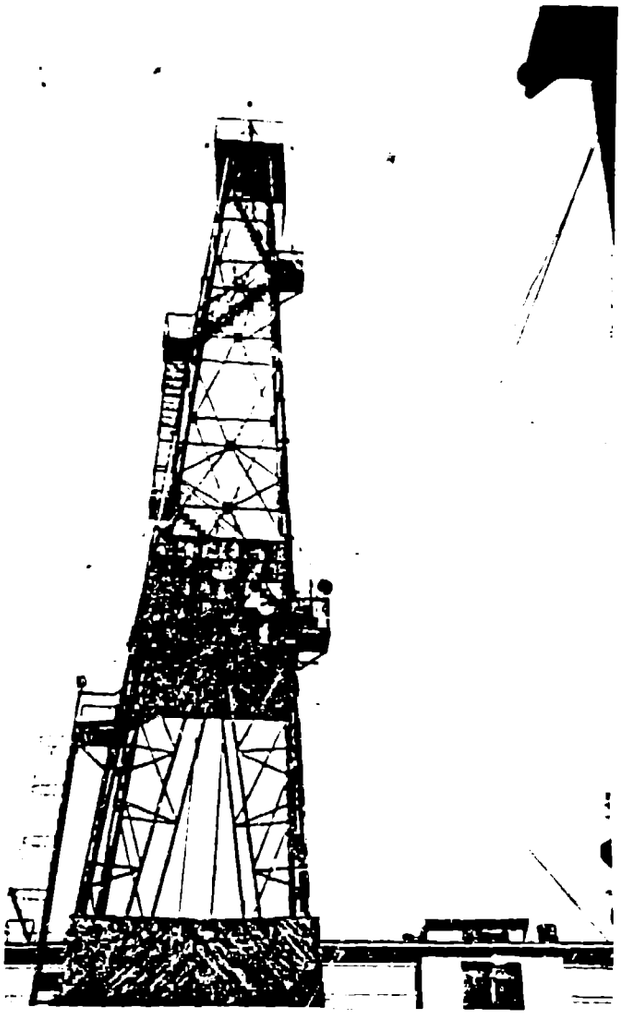


Fig. 9 - Derrick at drilling research laboratory, Ufa, Basnkiria.

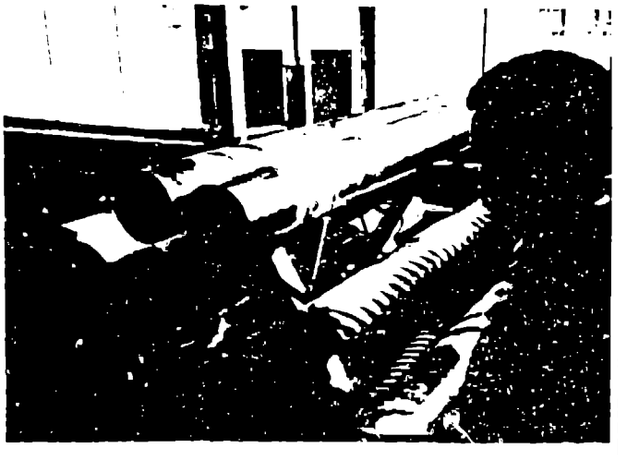


Fig. 10 - Nine-lobbed, positive-displacement development mud motors.

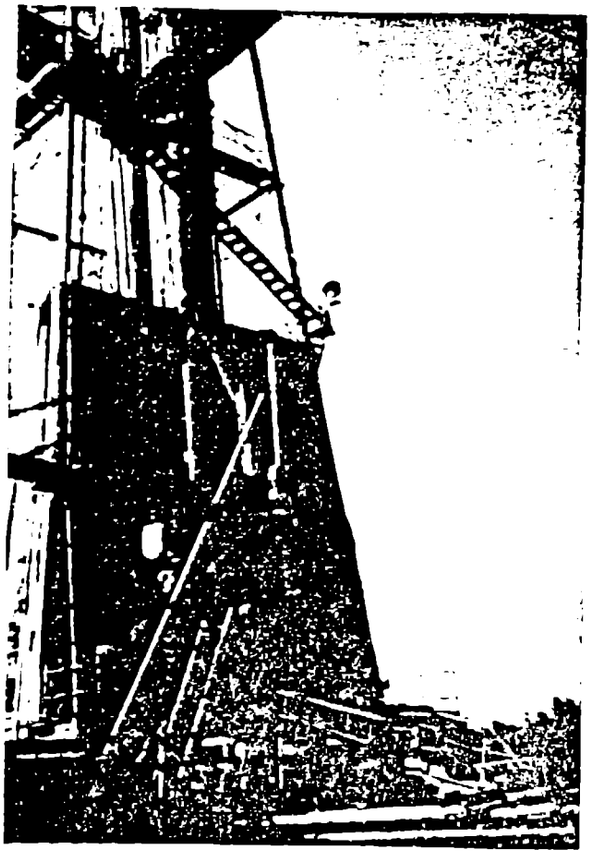


Fig. 11 - Big rig drilling stratigraphic well to 7-1/2 km (~ 24,000 ft).

FABRICATED FROM STEEL ANGLE
BASE 10 x 10 METERS
CAPACITY 500 TONS
5 km DEPTH*
MASS 55 TONS

*7.5 WITH ALUMINUM DRILLPIPE

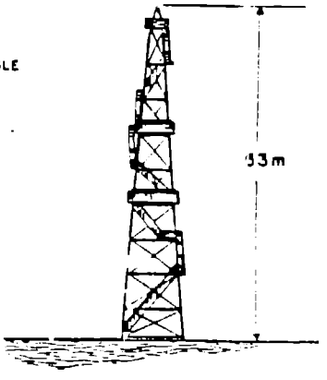
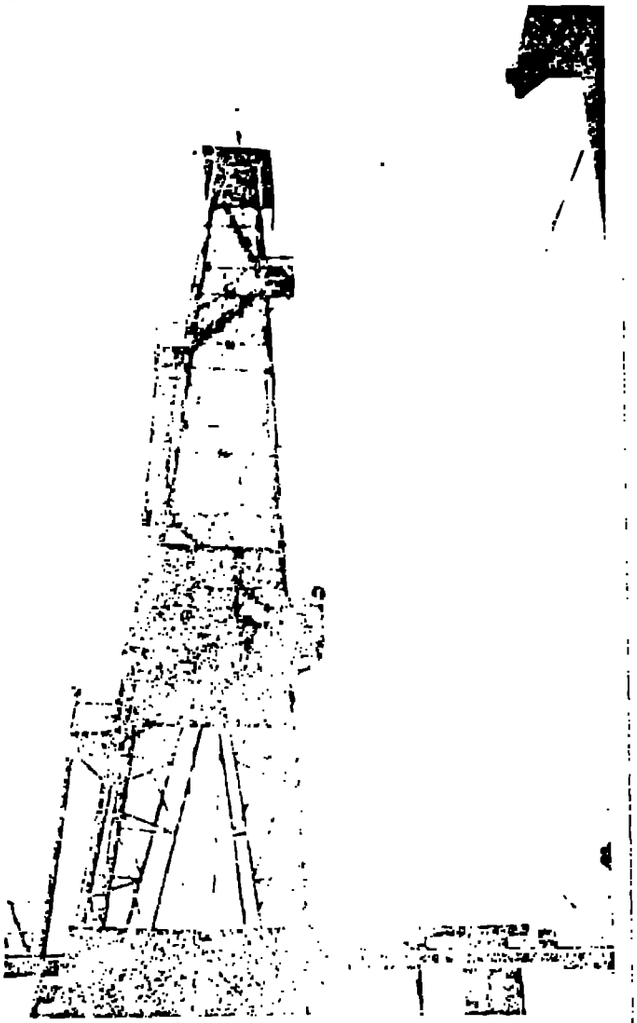
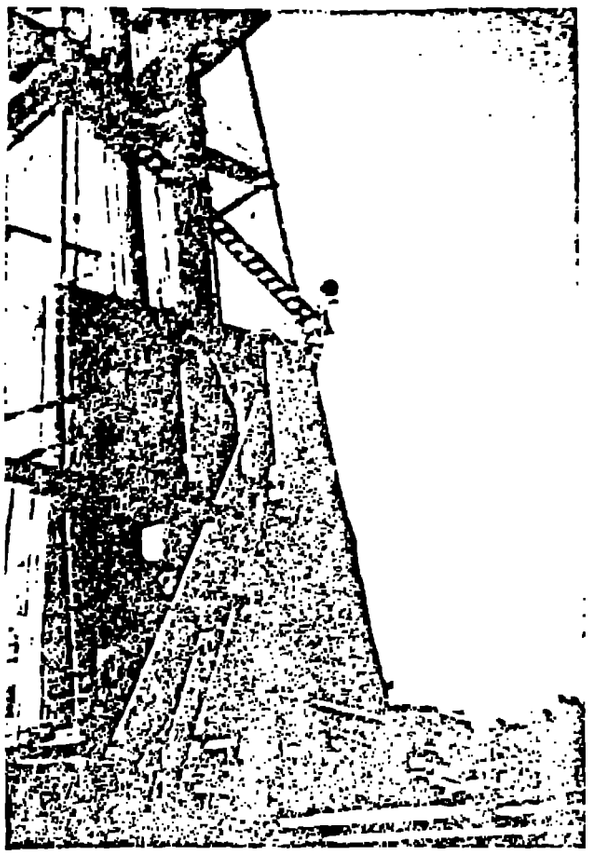
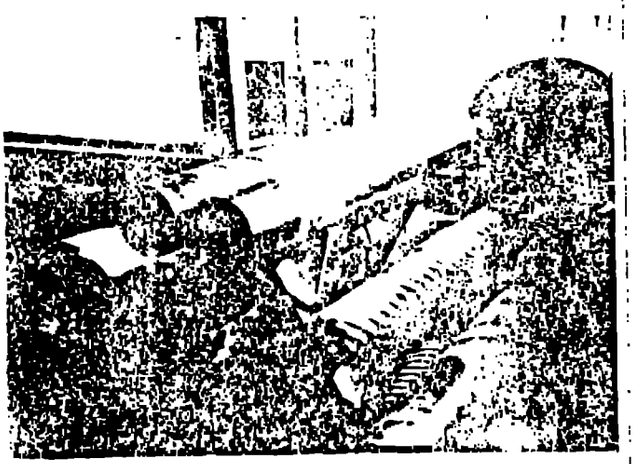


Fig. 12 - Diagram of V353-500 derrick and specifications.

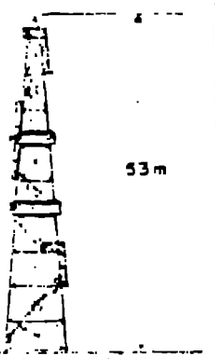


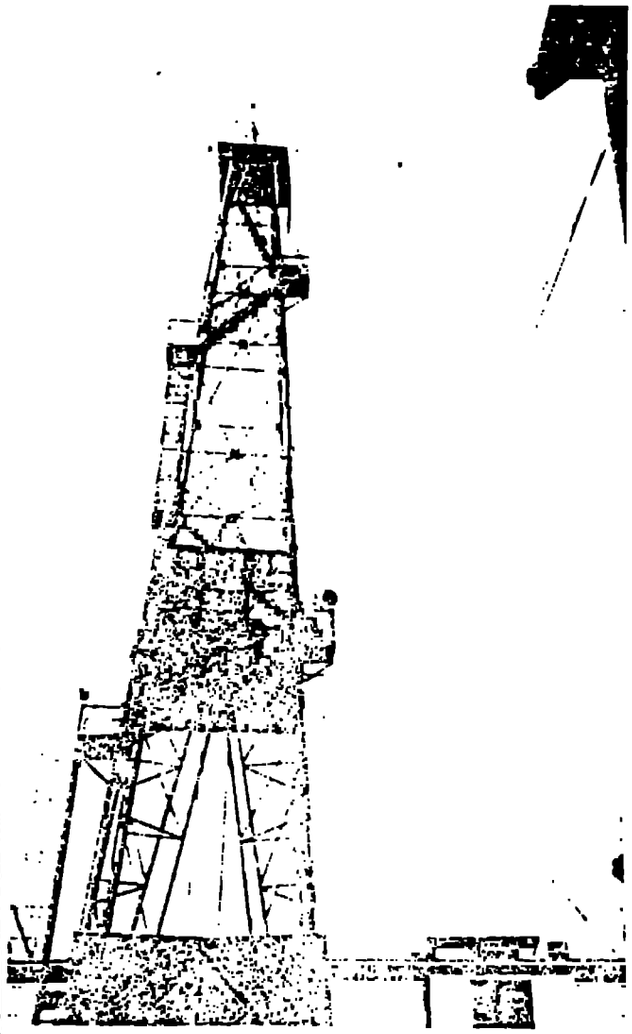




FABRICATED FROM STEEL ANGLE
BASE 0 x 0 METERS
CAPACITY [illegible] TONS
[illegible] m DEPTH*
MASS [illegible] TONS

*1.5 WITH ALUMINUM DRILLPIPE





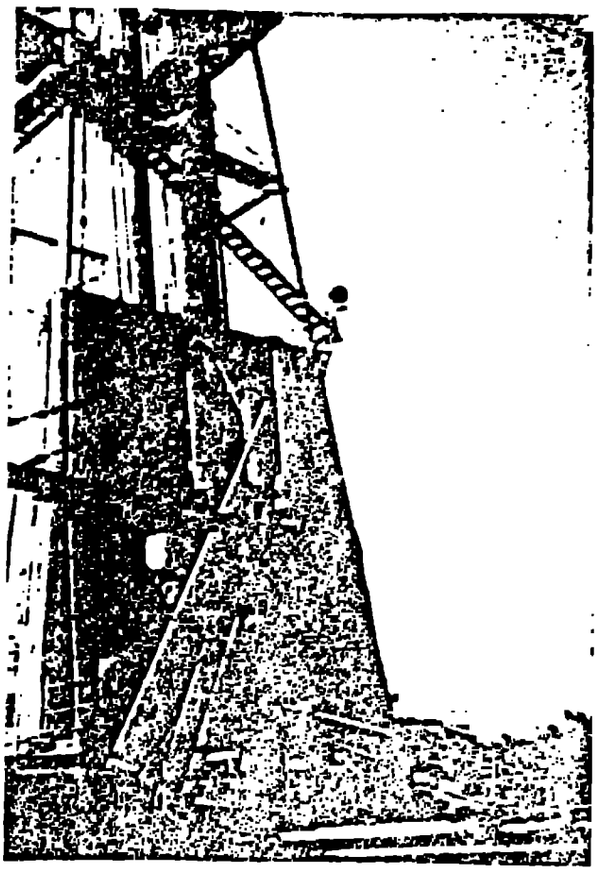


Fig. 11 - Big rig drilling [illegible]
well to [illegible] ft.

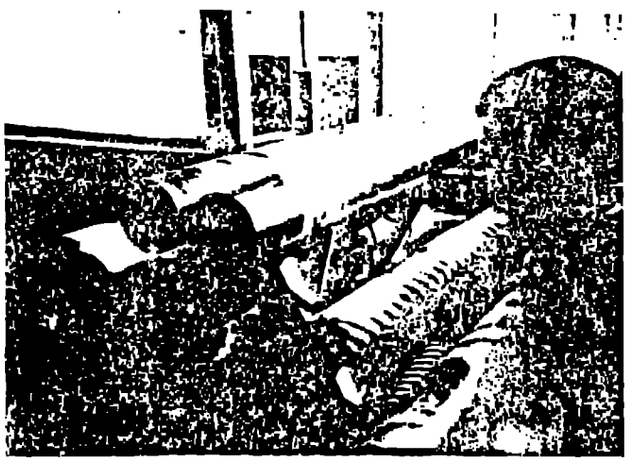


Fig. 10 - Nine-lobbed, positive-
displacement development mud motors.

FABRICATED FROM STEEL ANGLE
BASE 10 x 10 METERS
CAPACITY 500 TONS
5 km DEPTH*
MASS 55 TONS

*7.5 WITH ALUMINUM
DRILL PIPE

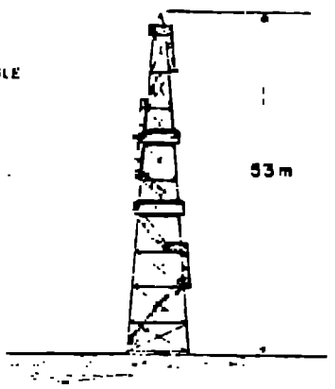


Fig. 12 - Diagram of 7333-500
derrick and specifications.